Silvicultural Guide Series

Jack Pine Working Group

Ontario
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PREFACE

Jack pine — the prodigal son of Ontario forestry; for years it was an undesirable species — Ontario's second most important commercial forest species, and no one wanted it.

For forest managers, though, jack pine is a rewarding species. Designate an area to be regenerated and plant the jack pine seedlings, and in five years a forester can walk through a thriving plantation. In a field where we do not often see the visible results of our efforts, jack pine management is a joy.

This publication presents a general, "all-purpose" approach to the jack pine working group because there is no one treatment for all sites across northern Ontario. It offers a description of the species' characteristics, and a discussion of current jack pine management prescriptions across the Boreal Forest. Although we know how to establish a jack pine plantation, there is still much to be learned in order to manage it effectively.

As further reading to this publication, I highly recommend the Canadian Forestry Service's Proceedings of the jack pine symposium, 1984. It was an invaluable resource in the preparation of this document.

Having survived the rigorous scrutiny of the Forestry Technical Review Committee, over a vigorous two-week period, I wish to thank Adrian Van Fraassen, Roger Davison, Frank Kennedy, Jukka Heikurinen, and Brian Nicks of E.B. Eddy Forest Products for their friendly and useful criticism. On a more personal note, I wish to express my gratitude to Chuck Heeney (Ret.) for his invaluable contribution. And to all those who have been kind enough to give me their comments and support, a special thanks.

Kirkland Lake, Ontario
November 25, 1985

Rob Galloway, R.P.F.

INTRODUCTION

As an economic resource, jack pine (Pinus banksiana Lamb) is a species that is second only to black spruce (Picea mariana (Mill.) B.S.P.) in importance to Ontario's forest industry. Each year it represents 28 percent of the total volume of timber harvested and 30 percent of the total stumpage of timber cut on Ontario Crown lands (Anon. 1984). Moreover, jack pine provides an excellent and early return on management investments because of its ease of management, rate of juvenile growth, and suitability to intensive management.

Since the mid-1960s, utilization of jack pine has doubled, leveling off in 1980 at approximately five million cubic metres per year, while softwood utilization as a whole has increased only one-and-a-half times. Of the total jack pine volume shipped, half goes to the sawmilling industry — as the primary processor — and half goes directly to pulpwood producers.

Jack pine represents 31 percent of all trees used for outplanting in the province (Anon. 1984); it also represents 95 percent of the area regenerated in the Ministry of Natural Resources (MNR) Northwestern Region, as well as 30 percent of the area regenerated in the MNR Northern Region (Kennedy 1984, Galloway 1984). The species grows well within the Boreal Forest.

The Silvicultural Guide to the Jack Pine Working Group describes both the silvicultural characteristics of the working group and the management strategies that are used in Ontario. The management prescriptions set forth are based on an integration of the most recent information compiled from forest research data, forestry science literature reviewed, field experience, and current Ministry management practices. They are to be used as guidelines to create the silvicultural ground rules for normal and modified operations in the timber management plan for each management unit. (See sample charts in Appendix III.)

Periodic revisions of this guide will be necessary as new developments in forestry evolve.

1.0 MANAGEMENT OBJECTIVES

a) To provide for a continuous supply of forest products to Ontario's forest management industry by ensuring that the jack pine working group is managed on a sustained-yield basis.

b) Within the constraints of a sustained yield, to meet or exceed the projected levels of wood demand for this working group, at an acceptable cost level that would be consistent with the size and quality requirements of the demand.

c) To promote integrated resource management of Ontario forests.

d) To provide site protection on ecologically sensitive sites.

2.0 CHARACTERISTICS OF THE WORKING GROUP

2.1 Range

Commercial stands of jack pine occur primarily in the Boreal Forest region; however, they also form a major part of the Boreal/Great Lakes-St. Lawrence Transition Forest in the Northeastern Region. Figure 2.1 shows the range of commercial jack pine stands (Rowe 1972).

Figure 2.1. The commercial range of jack pine in Ontario.

2.2 Site

In Ontario, jack pine grows on a wide variety of soil types ranging in texture from coarse sand to clays, with moisture regimes ranging from dry to very moist (Jones et al 1982). The best growth, however, has been observed on fresh to moderately moist tills ranging from very fine sands to clay. Optimum growth occurs on different sites as the geographic locations change (Cayford et al 1967). The wide ranges in timber productivity are directly related to the texture, moisture regime, and rooting depth of each site.

Jack pine also grows under varying climatic conditions. Thus, the jack pine's ability to adapt to several types of site and climatic conditions necessitates an equal diversity in the kinds of silvicultural practices that are used to manage it.

Where the species has regenerated naturally in a particular area, a direct correlation can usually be drawn between the natural regeneration and the history of fire in the area.

2.2.1 Description of Main Site Types

Very fine sand, silt, or clay loams

These sites are potentially the most productive sites for jack pine in the Boreal Forest. Site conditions result in rapid growth and shorter rotation periods. Under natural regeneration conditions, if wildfires do not occur the jack pine component of the forest will decline and be replaced by balsam fir (Abies balsamea (L.) Mill.), black spruce, white spruce (Picea glauca (Moench) Voss), and trembling aspen (Populus tremuloides Michx.). Jack pine may be the climax forest if the sites are burned repeatedly. This situation has been clearly demonstrated in the Lower English River area (southwest section of MNR's Northwestern Region) where numerous fires have resulted in the jack pine's natural regeneration extending to silt and clay soils. Although the abundance of non-marketable species and herbaceous growth on these sites, which occur after harvesting, increase management costs, the rapid jack pine growth and shorter rotation age may still make these sites a viable investment opportunity.

Loamy tills

These are productive sites usually with stones and boulders, and soil depths greater than 30 centimetres; they are extremely variable and support the jack pine along with black spruce, white spruce, balsam fir, trembling aspen, and white birch (Betula papyrifera Marsh.). Depending on the moisture regime, jack pine may or may not be the Forest

Resources Inventory (FRI) working group for the site, but such sites would fall under the definition of the Boreal mixedwood forest. Operational difficulties caused by stones, rock outcrops, topography, and moderate-to-severe herbaceous competition, combined with the marketability of the other species on the site, all contribute to increasing management costs as well as to a possible reduction in the regeneration success rate.

Outwash sand deposits

These moderately productive sites are the stereotypical jack pine site — ranging in texture from fine-to-coarse sands of varying depths with dry-to-fresh moisture regimes. The species grows in pure stands on the drier sites along with black spruce and balsam fir, and on fresh-to-moist sites with trembling aspen. Outwash sands are the easiest sites for jack pine management. Access and operability are excellent and little competition occurs; thus, management costs are low and success rates high.

Shallow sites

These sites have the same species associations as the other sites, but productivity is somewhat lower. They are predominantly shallow dry sites — soil depths are less than 30 centimetres — with textures ranging from coarse sands to clay loams. The depth of soil is not a limiting factor in the early stages of development; in the later stages, however, growth may be severely restricted due to the lack of soil. Shallow sites are also subject to periods of excess moisture and drought during the growing season.

2.2.2 Climate

Jack pine grows mainly in low-elevation areas, which are characterized by long frigid winters and short warm-to-cool summers with low rainfall. During the summers there are only a few days when temperatures attain 30-35 degrees Celsius. The frost-free period ranges from 80 to 120 days. The species ability to grow under such variable conditions is an advantage in its management.

2.2.3 Soils

Natural stands of jack pine occur primarily on podzolic soils. (The podzolization process is intense in the Boreal Forest as a consequence of cool temperatures and a predominance of precipitation over evaporation (Larsen 1980).) The species is also found on deep-to-shallow soils ranging in texture from coarse sandy gravel to clay. It grows

best on well-drained to moderately well-drained soils; and although it is usually found on acid soils, development may occur on calcareous materials (Armson 1977). Therefore, factors that will positively or adversely affect its growth are soil depths for rooting, soil aeration, soil temperature, soil nutrients, and amount of moisture. Jack pine is not a demanding species in terms of needing fertile soil to grow on, thus further demonstrating its adaptability and relatively easy manageability.

2.3 Silvics

2.3.1 Habitat

Jack pine is the most widely distributed Canadian pine, and can typically be found growing in extensive, even-aged stands that have developed out of burned-over areas caused by forest fires. As such, the pattern which emerges for the jack pine forest is rapid establishment as a monoculture over fire-prone sites (Cayford et al 1983) with subsequent invasion and establishment of black spruce and balsam fir.

Day and Woods, in 1977, presented a detailed description of fire-origin stands, which showed the successional trends ranging from pure jack pine stands at young ages to the final stage of an all-aged spruce-fir tolerant hardwood stand in the absence of fire. Therefore, jack pine has evolved into a pioneer species capable of withstanding the harsh environments following fire catastrophes. This may be of particular interest to managers who decide to regenerate jack pine under the clear-cut system where similar conditions exist.

2.3.2 Reproduction

Jack pine has inherent advantages of early sexual maturity, fecundity, and regularity of flowering. The serotinous cones facilitate cone collection, production of seed (Yeatman 1984), and maintenance of seed for release after fire or other disturbances.

In natural stands, the species produces male strobilii and female conelets beginning at age five. Seed years are frequent; and, because viable seed may be harvested from up to six-year-old cones (Baker 1980), large quantities of seed are available for regeneration purposes.

2.3.3 Establishment

The seed has no requirement for stratification. Germination of cleaned, filled seed commonly exceeds 95 percent at the Ontario Tree Seed Plant in Angus. Germination presents no unusual problems in nursery beds or in greenhouse container-stock programs. The ability of jack pine seed to withstand daily temperature extremes common to the climate of the Boreal Forest makes it suitable for broadcast seeding.

Germination under operational programs, such as in direct seeding, requires receptive seedbeds, as defined by Riley (1984), for mechanical site preparation:

a) exposed mineral soil with a firm base, or
b) a thin (less than 1.5 cm) duff/mineral soil mix which would readily settle to a firm base, or
c) firm mineral soil with a very thin duff cover, generally not more than 0.6 cm thick.

Air temperature of 17 degrees Celsius along with adequate moisture are also required for maximum germination.

Following germination, young seedlings are vulnerable to heat, drought, freezing temperatures — in particular during summer or early fall frosts — and frost heaving. They are also vulnerable to the devastation wreaked by insects, disease, rodents, and other animals (Yeatman 1984).

Microsites that provide partial shading without allowing vegetative competition for light and moisture are the most suitable sites for germinants' survival.

2.3.4 Development

Jack pine is well-known as a tree which grows rapidly in its initial 40 years and then shows a marked growth reduction, depending on the site and vegetation density. In 1981, Shea summarized jack pine's major growth characteristics as follows:

a) Overall productivity is moderate, but the species has relatively high initial growth.
b) The configuration of the growth/age curve is markedly affected by the site.
c) Jack pine develops undesirable branch and form characteristics if it is open grown; hence, there is a limited capacity to regulate stand density by increasing initial spacing.

d) The species develops considerable mortality during the intermediate stages of stand development due to inter-tree competition.

The biological characteristics of jack pine are such that the stage of development of the stand has a critical effect on the efficiency of a particular stand-improvement treatment.

2.3.5 Genetic Improvement

Close regulation of seed collection, distribution, and identification, as well as the designation of natural populations for seed production and genetic conservation, secure the genecological base for regional reforestation. (The seed collection and management system in use in MNR's Northwestern Region is an example of how the regulating is implemented (McIntyre 1984).)

Serious losses may be incurred by using an improper seed source or moving seed beyond the boundaries of recognized ecological zones. Such losses will be perpetuated in future generations if the seed is taken from incorrect sources (Yeatman 1984).

The basis for improvement of jack pine is the high level of genetic variability from tree to tree (Rudolph and Yeatman 1982). Future improvements are expected in stem straightness, branching characteristics, survival, wood quality, disease resistance, and growth.

Strategies chosen toward realizing genetic improvements are varied and reflect local choices and responses to geographic, technical, economic, and political factors. An example of a regional tree-improvement program has been described by Miller in the Canadian Forestry Service (CFS) Proceedings of the Jack Pine Symposium, 1984. Programs such as Miller's will continue to change and evolve under the direction of a strategic tree-improvement program.

The following is a summary of the tree-improvement strategy for jack pine in Ontario that has been proposed by Rauter (1984):

a) The Base Program (Strategy I) will be in effect until material is available from seed orchards. This step involves the establishment of gene pool reserves, seed production areas, and seed collection areas, and requires adherence to proper seed identification and transfer rules.

b) Seedling Seed Orchards (Strategy II) will be established for jack pine in the first generation. Collection of material for the establishment of these orchards will favour parent trees with good stem and branch form, absence of Cronartium galls, and superior growth rate.

c) Clonal Forestry (Strategy IV) will be practiced once economical and biological feasibility has been ascertained. If the program is successful 30-50 percent of planting stock in the year 2000 will originate from these clonal orchards.

2.3.6 Growth and Yield

As stated in section 2.3.4, two important features affect the growth and yield of jack pine: the effect of the site on the growth/age curves and the amount of mortality in the intermediate stage of tree development. Currently, there is still not enough information on either of these factors to furnish the reliable-yield data for jack pine. Table 2.1 summarizes data from Plonski's Normal Yield Tables (1974). As a comparison, Table 2.2 presents data — converted — from Evert's Management-Oriented Yield Tables for Jack Pine Cover Type in Northern Ontario (1976). (Heights of trees at age 30 were used to convert Evert's tables into Plonski's site classes.) For the purpose of comparison, the conversion to cubic metres is based on one cord equalling 80 cubic feet.

Although both publications present valuable yield data, further information will be required in order to produce yield data for plantation jack pine. Current research and development projects are investigating site-specific yield tables for jack pine.

The development of a biologically based jack pine stand growth-and-development model, which could be calibrated by total stand/stem analysis, is likely to be the most efficient method of obtaining "tailor made" timber production functions for jack pine (Shea 1981).

Table 2.1
Maximum Mean Annual Increment (MAI) Data by Site Class
Normal Yield Tables for Major Forest Species of Ontario by W.L. Plonski (Ontario Ministry of Natural Resources, 1960)

		When MAI Is At Its Maximum		
Site Class	Age (years)	Density (stems/ha)	GMV* m^3/ha	MAI m^3/ha
1	45	1431	178	3.96
2	60	1295	162	2.70
3	70	1431	127	1.81

*GMV -- gross merchantable volume.

Table 2.2
Maximum Mean Annual Increment (MAI) Data
Management Oriented Yield Tables for Jack Pine Cover Type in Northern Ontario by F. Evert (Canadian Forestry Service, 1976)

			When MAI Is At Its Maximum		
Site Class (age 30)	Initial Density (age 30)	Age (years)	Density (stems/ha)	GMV m^3/ha	MAI m^3/ha
1	618	57	472	173	3.04
	1235	65	804	263	4.05
	1853	67	1055	303	4.53
	2470	67	1231	323	4.82
	3088	67	1396	336	5.01
	3075	68	1512	349	5.14
2	618	60	446	122	2.03
	1235	80	684	218	2.72
	1853	80	891	242	3.02
	2470	82	1036	271	3.19
	3088	82	1112	272	3.32
	3705	84	1154	286	3.40
3	618	80	348	79	0.99
	1235				
	3705	90			

2.4 Suitability for Intensive Management

Many of the characteristics of the jack pine working group, which are outlined in this section, make it most suitable for intensive management. A number of its biogeographic features include:

a) High yields at early ages and, therefore, potentially shorter rotation ages (i.e. 50 years or less).

b) A wide natural range extending across most of northern Ontario.

c) A capability of growing on a wide range of soils as well as a tolerance of extreme climatic conditions.

d) A natural occurrence in extensive stands, making it suitable for monoculture practices.

e) A high level of geographic variability and tree-to-tree genetic variability, making it suitable for tree-improvement programs.

f) An ability to produce large quantities of seed frequently and at early ages.

g) An evolution of the species based on its adaptability to nature catastrophe, which makes it suitable for the clear-cut management system.

3.0 MANAGEMENT PRESCRIPTIONS

3.1 Silvicultural Systems

As described in section two, the silvics of jack pine requires a type of harvesting that creates an aftereffect similar to the devastation following a forest fire. Therefore, jack pine is managed exclusively under the clear-cut silvicultural system. This system involves the harvesting of a forest in a single operation, which removes most of the vegetation from the area and creates the ideal conditions for the establishment and survival of a new natural or artificially regenerated forest crop.

The Boreal Forest, for example, is a generally homogeneous forest of even-aged stands of intolerant coniferous and deciduous species, which is best managed using the clear-cut system. Since the last glacial period, extensive fires have swept this forest about every 100 to 150 years, continually recreating the ideal growing conditions for its regeneration.

Clear-cut logging disturbances can create similar growing conditions for regeneration.

Clear cuts can be of various shapes and sizes. The most common form is an irregular pattern, which is determined by rugged terrain, forest type, and the immaturity of age classes. The size of the pattern may be altered in order to protect ecologically fragile sites. Other forms include the strip-and-block patterns. Some strip-and-block areas are left uncut until the harvested areas around them have successfully regenerated to the free-to-grow stage.

The clear-cut system, which involves site preparation, regeneration, and tending of the new forest crop, perpetuates or produces an even-aged forest.

3.2 Harvest Methods

Three logging systems are used in the clear-cut harvest operation; and all three directly affect the kind of silvicultural treatment that follows the cut.

The shortwood logging system transports logs of preferred lengths to the roadside for loading and hauling. This type of harvest produces an even distribution of slash on the site. Under certain conditions, such as those in sawlog operations, it leaves behind so much slash that regeneration may be hindered.

The tree-length logging system, currently the most common, delivers trees to the roadside, with their limbs and tops removed. There, the tree lengths may be further processed into perferred-log lengths. Left-over tops and limbs are evenly distributed over the harvested area making their seed available for natural regeneration.

The full-tree-length logging system delivers full trees to the roadside for further processing into tree lengths or preferred-log lengths. Although this harvesting method produces large slash piles of tops and limbs, little of it is spread around the site and hence few seeds are dispersed for natural regeneration. Moreover, lack of slash around the site — or rather low fuel — limits the use of prescribed burns as a viable method of site preparation; though some mechanical site preparation costs may be reduced because of the lack of slash. Nonetheless, if the large slash piles are left unburned, it reduces the area available for renewal. This logging system is increasing in popularity.

3.2 Renewal

The process of renewal includes all the operations concerned with regenerating the forest after disturbance. Here, the operations are considered as a system, not as a group of separate silvicultural treatments. Appendix I outlines the typical silvicultural alternatives.

3.3.1 Site Preparation (SIP)

Site preparation is defined as the disturbance of the forest floor and the topsoil to create suitable conditions for natural regeneration, seeding, or planting (Anon. 1977).

It concerns four main objectives:

a) The reduction and removal of vegetation that competes with regenerating forests for light, moisture, and soil nutrients.

b) The reduction, removal, or alignment of slash in order to prepare the site for subsequent silvicultural treatments.

c) Control of the spacing and stocking of seedlings.

d) The creation of suitable microsites for the establishment and growth of the seedbed or planted seedlings.

The four site preparation methods used in jack pine regeneration are chemical, prescribed fire, mechanical, or any combination of the three.

Chemical SIP

Chemical operations involve applying herbicides to a site prior to regeneration treatments, and are usually used in conjunction with another SIP method. For example, sometimes they are used before a prescribed burn to enhance burning conditions; sometimes they are used before or after mechanical SIP to reduce herbaceous competition befeore planting.

Herbicides currently being used in northern Ontario are Roundup, Velpar, and 2,4-D. Each one is measured and applied at a rate consistent with the vegetation control requirements of the site. The best time of year for spraying is in late June or July when the vegetation is lush and in a stage of rapid growth. Acceptable results, however, may be attained throughout the frost-free period. Herbicide application is carried out by ground spraying units or by air. In the jack pine working group, 93 percent of all herbicide spraying is done by aircraft.

At present, chemical SIP represents only 6 percent of the total site preparation program (Dennis 1984).

Prescribed burn

This operation involves the controlled burn of a designated area in order to reduce slash or vegetation and prepare a suitable microsite for the regeneration treatment. Some burned areas may receive a follow-up treatment of mechanical SIP.

The objectives of a prescribed burn are:

a) To reduce fire hazard.

b) To prepare the site for natural or artificial regeneration.

c) To promote the growth of desirable species.

d) To remove undesirable species.

McRae (1979 and 1985) outlines the silvicultural aspects of prescribed burning. Decision-analysis tools, as described by Fullerton and Martell (1985), and operational planning guidelines, outlined by Isherwood and Macquarrie (1985), should ensure knowledgeable use of prescribed burns. The Prescribed Burning Manual (MNR 1980) presents the procedures for prescribed burning in Ontario and stresses that optimum and minimum values should be set for each objective. Fig. 3.1 shows the relationship between fuel consumption and the Buildup Index for jack pine logging slash, adapted from Stocks and Walker (1972) by McRae (1979). Tools such as these allow forest and fire managers to estimate the success of prescribed burns.

Prescribed burning represents 8 percent of the total site preparation for the jack pine working group (Dennis 1984).

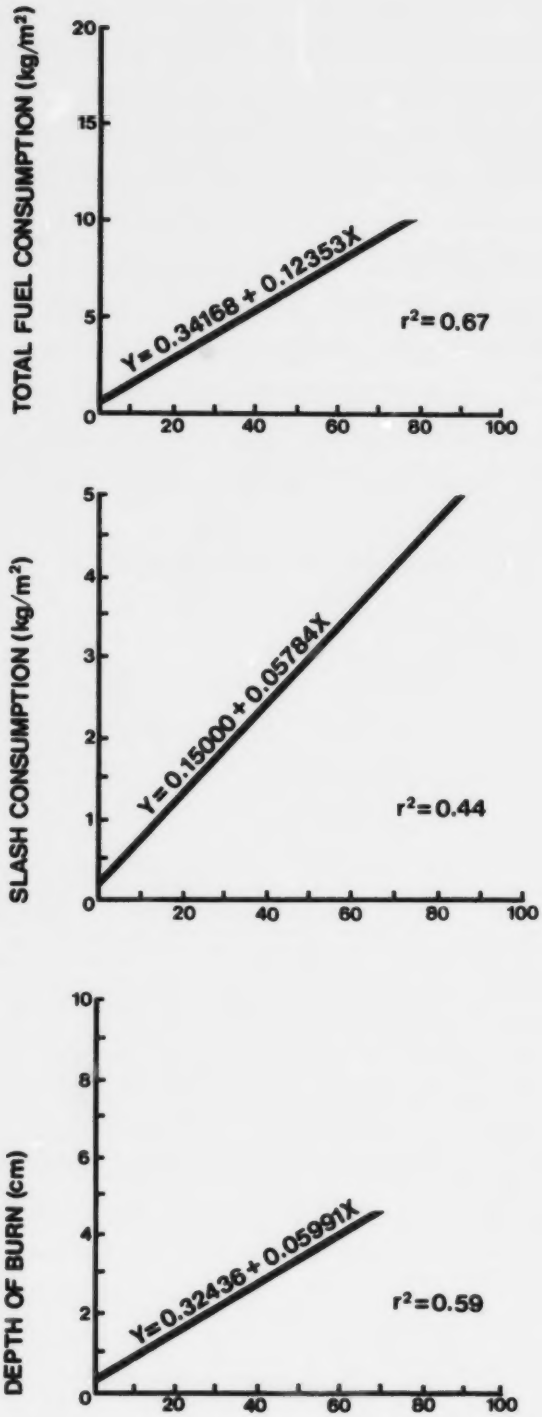

Figure 3.1. The relationship between different fuel consumption parameters (total fuel consumption, slash consumption, and depth of burn) and Buildup Index (BUI) for jack pine logging slash.

Mechanical SIP

Mechanical SIP involves the use of a prime mover to push, pull, or drag a piece of equipment around a site which is being prepared. Appendix II surveys the types of systems and equipment currently in use in the management of jack pine.

The choices of mechanical SIP equipment should be based on the following factors (Forest Resources Policy and Procedure Directives Manual, MNR 1984):

a) topography;
b) soil texture and moisture;
c) ground overburden — duff, vegetation, residuals, slash, stone;
d) follow-up prescriptions;
e) available equipment;
f) cost.

Depending on the choice of equipment, SIP may have a modifying effect on elements which affect seedling performance such as light, temperature, vegetative competition, and soil composition.

Because of the wide ranging climatic and site conditions in northern Ontario, there is no universal management prescription. Nevertheless, mechanical SIP must be site specific; that is, the SIP must be selected based on a knowledge of the specific site (McMinn 1984).

The successful seeding of jack pine (50 000 seeds per hectare) requires a 25 percent suitable seedbed which is uniformly distributed over the area (Riley 1980). Jack pine planting projects aim for 2500 spots per hectare (Rudolph 1950, Brown 1984) where sites allow.

Mechanical site preparation represents 86 percent of the total site-prepared areas of the jack pine working group (Dennis 1984).

The establishment and monitoring of SIP standards is vital to the biological and economic evaluation of any mechanical SIP project. Brown (1980) and Sutherland (1980) outline various methods of monitoring site preparation. For further information on these methods and SIP in general, the following publications are recommended: Forest Resources Branch Policy and Procedure Directives Manual (MNR 1984); Silvicultural Equipment Reference Catalogue for Northern Ontario (MNR 1980); Silvicultural Notes (MNR ongoing); and Canadian Forestry Service Equipment Information Bank (CFS ongoing).

3.3.2 Regeneration

Regeneration may be achieved by natural or artificial means. Natural regeneration relies on natural seed sources such as the cones from harvested trees. Artificial regeneration involves either the sowing of seed or the planting of tree seedlings.

Natural regeneration

This treatment involves scarification of the site to provide a suitable seed bed and to scatter the cones. Its success depends on viable seed from the previous stand being available; therefore, areas that are full-tree logged are not suitable. Natural regeneration eliminates the use of any improved seed.

The MNR Northern and Northeastern Regions have had little success with natural regeneration. Results improve, however, as one moves westward across the province. At present, natural regeneration accounts for 6 percent of the jack pine working group regenerated. The use of this method is decreasing as we move into more intensive forest management.

Seeding

In the jack pine working group, there are two main techniques used for seeding: aerial seeding on site-prepared ground, or ground seeding in conjunction with SIP. Seeding requires a suitable seedbed, as described in section 2.3.3, for mechanical SIP and favourable weather conditions for successful germination and establishment. Currently, forestry research is trying to determine what constitutes an acceptable seedbed and how many seed are needed to regenerate burned areas (Riley 1985).

When ground seeding using equipment like the Bracke Scarifier-Seeder or seed barrels (Clark 1984), two problems may develop: has the scarifying equipment prepared a suitable microsite, and has the seed actually been deposited on the proper location. Success rates with this method vary; however, lower cost makes it an appealing alternative for the lower-class sites where it may not be desirable to invest as much time and money.

Successful aerial seeding also requires a suitable microsite and is directly affected by the following operational factors:

a) Seed distribution and calibration guidelines should be used to set up any aerial seeding project. (The guidelines are given by Foreman and Riley (1979).)

b) Application rates and the percentage of mineral soil exposure (MSE) may be directly related to stocking levels (Riley 1980).

c) Receptive seedbeds of 20-25 percent will meet the stocking standards for jack pine (Anon. 1981), if sown at 50 000 seeds per hectare on mechanically prepared sites. An increased percentage of receptive seedbeds will increase stocking, but costs for SIP may become prohibitive.

Overstocking may occur if sites are over-prepared and excessively seeded. Where seeding on a receptive seedbed appears to have failed, decisions concerning this failure should be delayed up to three years, or until the seedbed is in danger of becoming non-receptive. Furthermore, jack pine stocking may increase due to ingress or delayed germination (Riley 1980). Seeded areas may require periodic juvenile thinning to reduce the number of stems per hectare.

Seeding represents 70 percent of Ontario's annual area regenerated in the jack pine working group (see Appendix II).

The Forest Resources Branch Policy and Procedure Directives Manual (MNR 1984) covers the requirements and methodology for regeneration by seeding.

Planting

Planting involves putting the seedling into the ground either by hand or by machine. The seedlings may be either bareroot or container stock. It requires the preparation of a suitable plantable spot where a bareroot or containerized seedling can be placed. Control of seedling spacing, high regeneration rates, and the opportunity to use genetically improved stock all contribute to make planting a good choice on most sites (Galloway 1984).

Successful establishment of jack pine by planting is a multi-step operation which must overcome various biological and operational problems. (For example, there is no operational machine planting in northern Ontario at present.) Pletch (1984) summarizes this operation in the following manner.

a) Quality stock is supplied by the grower; that is, stock that has been well-grown and well-handled (Hutchison 1984).

b) The stock is then carefully handled on the site. (Guidelines for the handling of jack pine bareroot and container stock are available and periodically reviewed as new information develops; see the MNR Northern and North Central Region Stock Handling Guidelines.)

c) Suitable microsites are prepared for planting.

d) The kind of planting and its respective quality are determined.

e) A site is planted. The site should contain 2500 stems per hectare, or equivalent, of jack pine plus other crop species (Rudolph 1950, MNR 1984).

Plantations should be monitored until they have reached the free-to-grow stage.

Stock currently being outplanted is either 2-0 bareroot stock or container stock at various stages of growth. The trend seems to be toward container stock because of the higher regeneration success rates achieved with containers (Heikurinen 1984) and the ease as well as cost benefits of the planting operation. In addition, it appears that the root deformation, which occurs in containers, does not adversely affect jack pine growth. Mattice (1982) indicates that the performance of jack pine in containers is better than bareroot jack pine during the first three years; after that, it begins to slow down.

Planting represents 24 percent of Ontario's annual area regenerated in the jack pine working group (see Appendix II). Currently, forest managers are inclined to plant, especially on the better sites and on areas of intensive management.

Fig. 3.2 shows how decisions concerning regeneration can be determined in chart form.

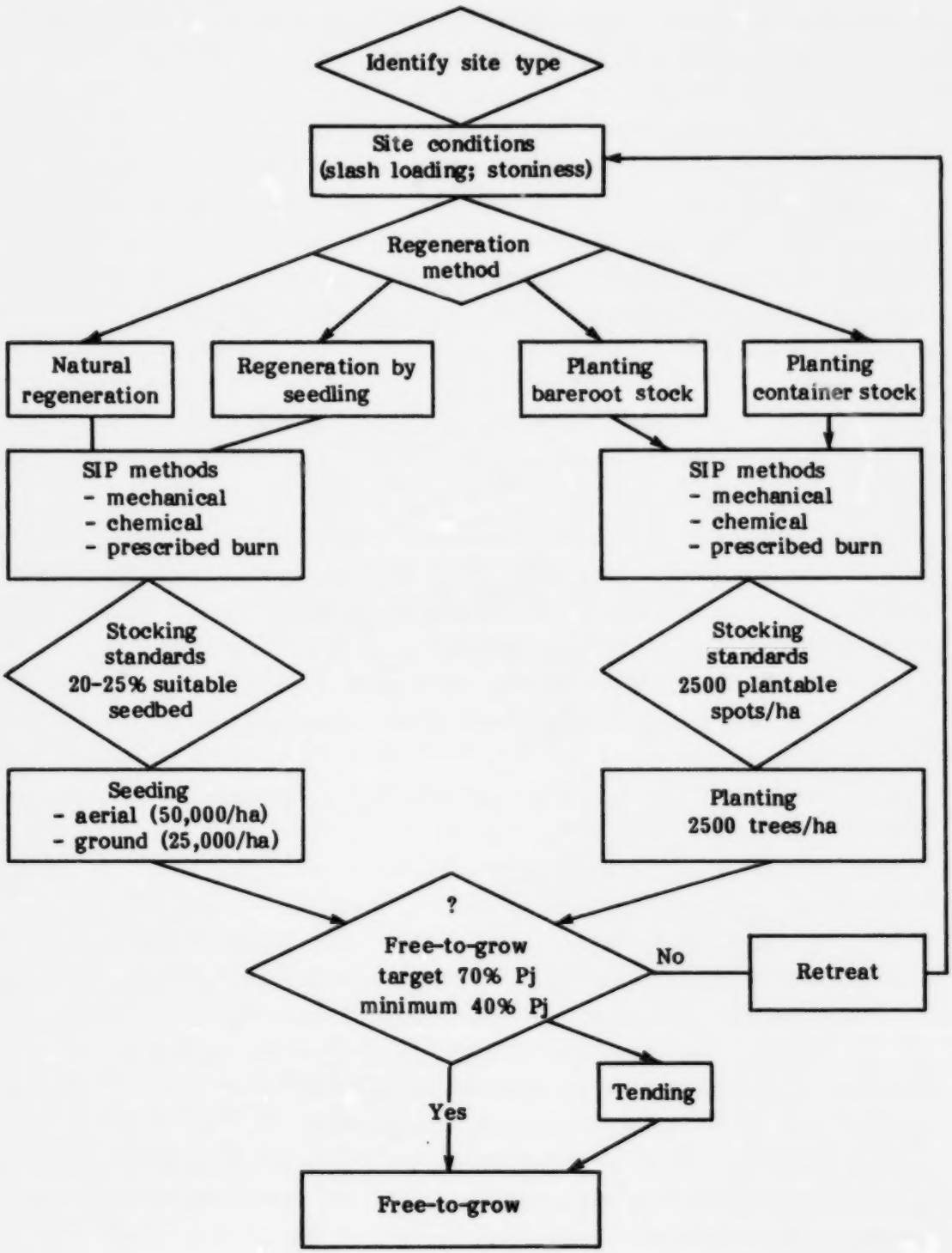

Figure 3.2. Decision model for regeneration of jack pine.

3.4 Stand Maintenance

Stand maintenance is the tending and protection operation designed to ensure survival and development of the stand to maturity.

Tending "cleans" the stand of undesirable species; thinning is the part of the operation that removes excess trees from an overstocked stand for the purpose of providing free-to-grow conditions for the other trees.

Protection involves the control of forests pests such as insects, disease, and rodents. Fire prevention and protection — though of the utmost importance in timber management — is not considered part of this operation; it is a separate entity and as such has its own operation and planning guidelines.

3.4.1 Tending

Cleaning

Weed competition will usually reduce the growth or cause mortality of young jack pine trees. Cleaning is part of "protecting the investment."

Vegetation-control management strategies are outlined as follows (Dennis 1984):

a) Manual cleaning, which is labour intensive, is not economically or physically feasible except on areas where operational or environmental constraints limit the use of herbicides. Neither manual nor mechanical cleaning eliminates root competition.

b) Mechanical cleaning can be an effective but costly method; it can also injure the trees.

c) Prescribed burning can be effective as a pre-regeneration treatment, but it is not feasible on the scale cleaning is required.

d) Chemical release is cost effective, with high productivity and long-term effectiveness. Results can be erratic, however, if the chemicals are not accurately prescribed and properly applied at the correct time. Chemical tending must occur only after the jack pine has hardened off.

e) Any combination of the above management strategies.

f) None of the above management strategies.

The choice and cost of these alternatives will depend on management objectives, species and age of competing vegetation, topography, site conditions, and environmental constraints (Jaciw 1969).

The following publications should be of value in the planning of any herbicide application: Aerial Spraying for Forest Management — An Operational Manual (MNR 1981); and "Policy and Procedure Directives for the Aerial Application of Herbicides", Forest Resources Branch Policy and Procedure Directives Manual (MNR 1984).

Thinning

Thinning a stand has a positive effect on the growth and form of the remaining jack pine trees (Smith 1984) of virtually all ages, in particular because the space is needed for its branching and crown development habits.

Thinning costs are lowest in the 10- to 15-year-old stands — the age of maximum growth (Riley 1973) — thus producing the best biological and economic results. Forest research and development is currently exploring whether we can significantly reduce rotation ages and justify the economics of thinning (Nicks 1983, Beckwith and Robbelin 1984) at either the juvenile or intermediate stand-development stages. There is little data available at present to justify thinning jack pine on a large operational scale.

3.4.2 Protection

Insects (Howse 1984)

Although there are at least 58 insect species or groups that are found on jack pine in Ontario, 25 of these cause significant damage to the tree and another five are considered a serious management problem.

a) Jack pine budworm (Choristoneura pinus Free) is the most serious problem insect affecting Ontario jack pine. Its population dynamics are not yet fully understood. Outbreaks of the pest usually last 2 to 4 years and then suddenly end. Population buildups may occur quite suddenly on a widespread or local basis; they appear to be related to the occurrence and abundance of male flowers on mature trees. A dramatic increase in the overall insect population has been occurring since 1983. In 1984, insect infestation moderately to severely defoliated 1 150 158 hectares of jack pine, and reached a high of 3 660 069 defoliated hectares in 1985. The only means of controlling this pest is through the application of insecticides. Fenitrothion and Bacillus thuringiensis (B.t.) have been approved for aerial application.

b) Swaine jack pine sawfly (Neodiprion swainei Midd.) has damaged large areas of timber over the last 30 years. In 1981, infestations covered 5700 hectares, decreasing to 518 hectares in 1983. Susceptible stands appear to be site-class

3 jack pine on shallow soils. Control may be achieved by cutting the susceptible stands or by applying fenitrothion, which is the only registered insecticide for use against this pest.

c) Sawyer beetle (Monochmus spp.) adults feed on the bark and twigs of mature and immature jack pine along the edge of cut areas. Damage from sawyer beetles occurs when logging-slash buildups offer ideal circumstances for population buildups. Similar population increases have been observed in fire-damaged stands. Control is virtually impossible, but limiting slash piles near live trees appears to eliminate most of the damage.

d) Eastern pine shoot borer (Eucosma gloriola Heinr.) was the most frequently detected insect in the jack pine plantation survey. Although 39 percent of the stands were infested, only 10 percent of the leaders were damaged. Trees under 6 metres appear to be favoured.

e) White pine weevil (Pissodes strobi Peck) has been found in 35 percent of jack pine plantations. Average leader mortality is less than 1 percent; however, in certain plantations damage may be as high as 11 percent.

Diseases

Jack pine is a relatively hardy species with many disease enemies. Yet none has been widespread or caused serious damage. The pathology of Ontario jack pine is characterized by local damages and losses primarily due to decay, caused by Phellinus pini; cankers, produced by Scleroderris canker (Gremmeniella abietina Lagerb Morehet); and the sweet-fern blister rust (Cronartium comptonial Arth.) (McGauley and Gross 1984).

Stands less than 60 years old have less than 1 percent cull.

a) Scleroderris canker is not considered an economically important pathogen of jack pine. However, on trees of poor vigour it can develop and cause mortality. Nursery seedlings should be handled with care to minimize damage (McGauley and Gross 1984).

b) Sweet-fern blister rust: Although its control is not practical, management techniques may reduce damage. Trees older than one year appear to be sweet-fern resistant. This means that container stock should not be planted in areas where high populations of sweet-fern exist. Twelve metres from patches establishes a boundary of low-risk exposure (Gross et al 1980). Nursery stock should be kept infection-free.

c) Western gall rust (Endocronartium harknessii (J.P. Moore) Y. Hirut) causes round stem galls on young pines, and branch galls on jack pines of all ages. Gall rusts may cause mortality of seedling-sized pines. Instances of 5 percent mortality have been observed in Ontario (Howse et al 1981).

Fig. 3.3 shows how decisions concerning stand maintenance can be determined in chart form.

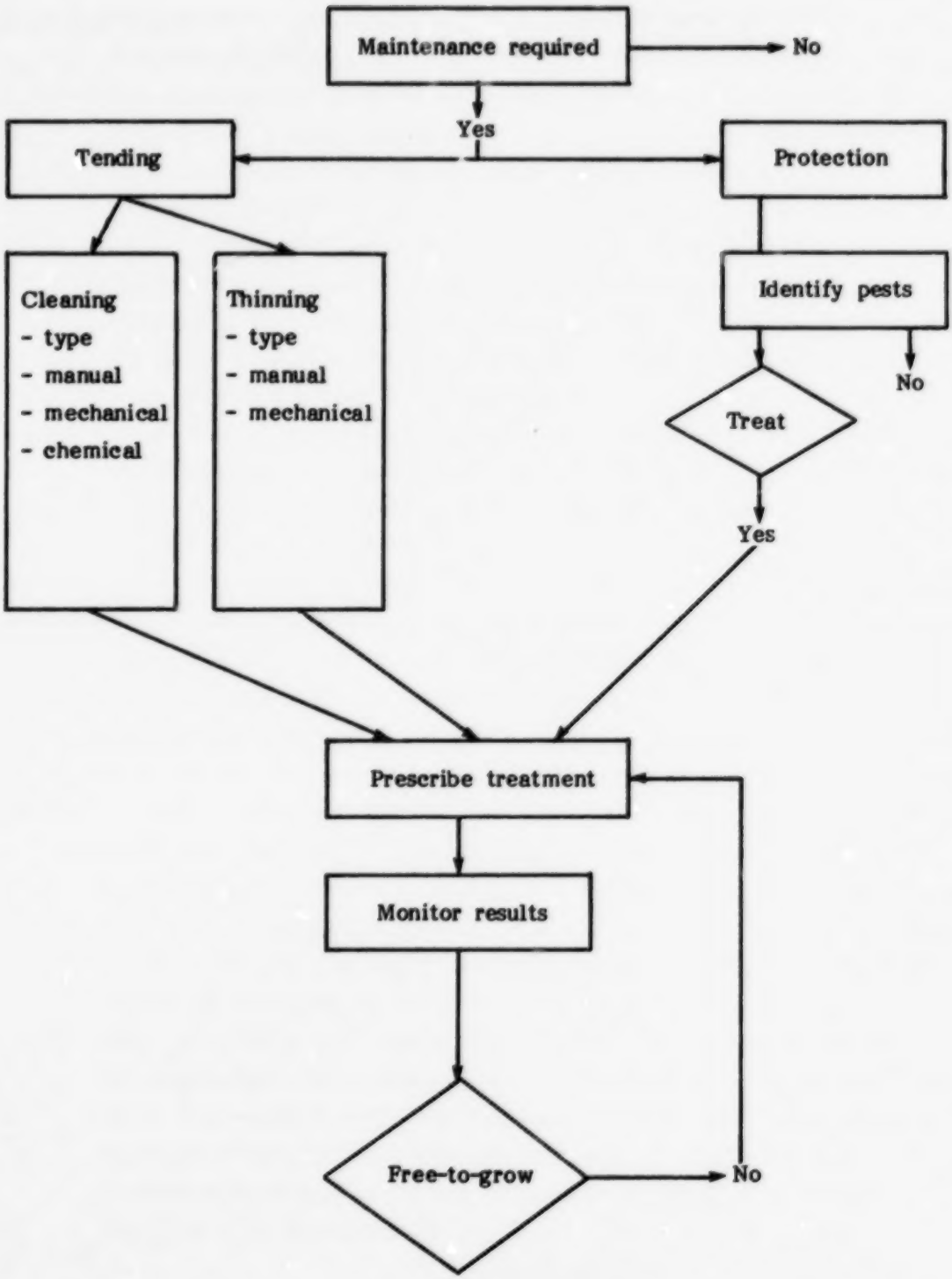

Figure 3.3. Decision model for jack pine stand maintenance.

APPENDICES

Table 4.1
Silvicultural Practices

Type of Site	Site Preparation (SIP) Alternatives	Regeneration Alternatives	SIP Standards for Regeneration Type	Tending Probability and Alternatives
Outwash deposits	–Light site preparation, (Bracke, T.T.S. disc, barrels and chains) –Prescribed burn (but care must be taken not to harm the site by extreme burn) –Chemical SIP	–Planting (bareroot or containers –Seeding (aerially or by ground) –Natural (may be possible on some sites and locations	–2500 spots/ha –20% to 25% mineral soil exposure (MSE)	–Probably not required –Perhaps thinning
Loamy tills	–Heavier site preparation is required to reduce competition; sites have more slash and some stones (heavy barrels and blades, plow, Young's teeth, T.T.S. disc) –Prescribed burn SIP –Chemical SIP	–Planting (bareroot, if not too stoney, or containers) –Seeding (aerially or by ground	–2500 spots/ha –20% to 25% MSE –2500 plantable spots/ha	–Probably will be required at 3 to 5 years; herbicide application to reduce poplar, birch and cherry competition
Shallow sites	–SIP is restricted by rocks and prime-mover capability (Bracke, T.T.S. disc, Young's teeth, light drags) –Prescribed burn SIP –Chemical SIP	–Planting (containers) Seeding (aerially or by ground –Natural (if cones are available)	–As many spots as possible (1500 to 2000 spots/ha) –20% to 25% MSE	–Tending is not likely to be required
Silty or clayey sites	–Heavy SIP is needed to reduce competition (Young's teeth, blades, T.T.S. disc) –Light SIP for minimum disturbance (T.T.S. disc, Bracke, light barrels) –Prescribed burn SIP –Chemical SIP	–Planting (bareroot at 2500/ha) –Planting (bareroot at 1200/ha) –Planting (bareroot)	–2500 spots/ha –1200 spots/ha –2500 spots/ha	–Tending is required to reduce grass and raspberry competition –Tending is required to control poplar and mixedwood stand anticipated competition –Tending required as in the first option

II. CURRENT SILVICULTURAL SYSTEMS AND EQUIPMENT

Table 4.2
Regeneration Treatments and Success Rates in the Northeastern Region

Silvicultural Treatment	Number of Trees (millions)	Area Annually Treated (hectares)	Survival Rate (percent)	Jack Pine 5th-year Stocking (percent)
Bareroot	1.0	325	80	-
Containers	6.2	900	93	-
Seeding	-	800	-	54

Table 4.3
Regeneration Treatments and Success Rates in the Northern Region (to 1982)

Silvicultural Treatment	Number of Trees (millions)	Area Annually Treated (hectares)	Survival Rate (percent)	Jack Pine 5th-year Stocking (percent)
Bareroot	6.1	3299	75	68
Container (paperpot)	16.4	1587	80	76
Seeding	-	3273	-	59

Table 4.4
Regeneration Treatments and Success Rates in the North Central Region (1976-1981)

Silvicultural Treatment	Number of Trees (millions)	Area Annually Treated (hectares)	Survival Rate (percent)	Jack Pine 5th-year Stocking (percent)
Planting				
- bareroot	2.7	1250	65-75	62
- container*	9.1	210	65-75	55
Seeding	-	3350	-	56
Scarification for natural regeneration		2490	-	41
No treatment	-	-	-	14

*Spencer-Lemaire

Table 4.5
Direct Seeding Stocking Percentages Compared to Untreated Cutover Percentages in the Northwestern Region

Silvicultural Treatment	Third-Year Stocking		Fifth-year Stocking	
	Jack Pine (percent)	Jack Pine and Spruce (percent)	Jack Pine (percent)	Jack Pine and Spruce (percent)
Direct seeding	45	53	47	55
Natural regeneration	n/a	n/a	12	29

Table 4.6
Site Preparation Equipment Used for Planting and Seeding in the Northern Region and the Area Treated Annually

Silvicultural Equipment	For Planting (hectares)	For Seeding (hectares)	Sub-total (hectares)
Young's teeth	1590	2050	3640
Bracke	1123	779	1902
Barrels and chains	900	267	1167
Straight blade	472	70	542
T.T.S. and Leno discs	25	81	106
Other	58	43	101
Prescribed fire	595	22	617
Total	4763	3312	8075
Percent	59	41	100

Table 4.7
Site Preparation Equipment Used for Planting and Seeding in the Northwestern Region and the Area Treated Annually

Silvicultural Equipment	For Container Planting (hectares)	For Bareroot Planting (hectares)	For Direct Seeding (hectares)	Sub-total (hectares)
T.T.S. disc	311	388	1 209	1 908
Barrels and chains	625	474	5 807	6 906
Straight blade	10	342	95	447
Bracke	124	45	2 534	2 703
Brush cut plow	6	23	242	271
Prescribed burn	5	3	165	173
No mechanical SIP	12	44	1 628	1 684
Total	1093	1319	11 680	14 092
Percent	8	9	83	100
Other*	208	544	8 268	9 020

* Includes wildfire, root rakes, Rome discs, pads and chains, and mechanical SIP not coded.

Silvicultural equipment used in the North Central Region includes: T.T.S. discs, barrels, Young's teeth, Bracke, Leno discs, and equipment for prescribed burns (Davison 1984).

Silvicultural equipment used in the Northeastern Region includes: T.T.S. discs, Young's teeth, Bracke, modified Martini plow, and equipment for prescribed burns (Heikurinen 1984).

III. SILVICULTURAL GROUND RULES

Normal Operations

For the Five-year Term from ____ to ____: _____ M.U./Forest

F.R.I. WG	SITE DESCRIPTION	Prop. WG/FU	Silviculture System	Method of Harvest	RENEWAL TREATMENT DESCRIPTION	STOCKING STANDARDS			MAINTENANCE TREATMENT DESCRIPTION
						To Prop. WG/FU		Min. To Accept. Species	
					Site Preperation/Regeneration	Min.	Des		Tending/Protection

Modified Operations

For the Five-year Term from ____ to ____: _____ M.U./Forest

PHYSICAL FEATURE OR VALUE	TIMBER MANAGEMENT PRESCRIPTION

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